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ASSESSMENT OF WATER POLLUTION USING THE WATER QUALITY INDEX (WQI) IN AQUATIC ECOSYSTEMS

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ABSTRACT

"Water is life," the old adage goes, and "water quality is health." For early identification of water habitat degradation and overall perturbations to aquatic ecosystems, it is vital to conduct water quality and aquatic ecosystem health assessments. The purpose of this research is to use the Water Quality Index (WQI) to determine the extent to which certain aquatic habitats are polluted. Over the course of six months, water samples were taken from five separate locations and tested for important water quality indicators. Findings show a wide range of pollution levels (WQI values 45–85), identifying problem locations and possible places to focus cleanup efforts.

Keywords: Water quality, Pollution, Aquatic ecosystem, Health, Environment

I. INTRODUCTION

Physical, chemical, and biological properties are the most widely used criteria for evaluating water quality on a worldwide scale. In addition to providing a home for a wide variety of plant and animal species, water is essential for human consumption, irrigation, many industrial operations, and the farming of shellfish, crustaceans, and fish. How the water is used affects its quality. The quality could be passable for consumption, but it wouldn't be ideal for anything else. Some crops would benefit from its irrigation, while others wouldn't be a good fit. Water quality is dependent on its constituents and whatever else the water may have absorbed during runoff; in contrast to water quantity, which is measured by a single parameter (such as water mass or volume), thus water can be ideal for cattle but terrible for fish farming. The local ecosystem and land usage are major factors. Water quality may also be significantly affected by changes in temperature and the alteration of natural stream flows. Keep contaminated sources (such as urban or industrial waste dumps) at least a safe distance away from groundwater, as it is a significant water supply. A wide variety of aquatic species call the waterways of lakes, rivers, and streams home. In an ecosystem, many living things, such as plants, animals, fungus, and bacteria, work together and are constantly influenced by their surroundings. Therefore, in order to keep water pure, it is crucial to safeguard aquatic habitats. As a vital component of our ecosystem, aquatic components are responsible for preserving water quality and are often used as a reliable indication of that condition. Around the world, bioassessment makes use of physical and chemical water quality indicators such as temperature, turbidity, color, salinity, dissolved solids, suspended solids, pH, nutrients, heavy metals, hardness, alkalinity, and biological water quality indicators such as total biomass, macrophytes, bacteria, macroinvertebrates, fish, and algae/total chlorophyll.

So, various methods exist for describing and evaluating water quality (e.g., based on physical, chemical, or biological properties). Listing the amounts of all substances present in the sample in accordance with the water quality standard guideline is one approach to describing the sample's quality. One alternative is to create a water quality index (WQI), which is a single number that represents the aggregated measurements of water quality parameters and indicators. This simplifies the data associated with water quality. When it comes to controlling water quality, WQIs are the better option. Consequently, authorities have vigorously supported the development and implementation of indexes. In addition, once implemented, WQIs provide a handy tool for analyzing patterns, drawing attention to certain environmental factors, and assisting policymakers in tracking the success of regulatory initiatives.

II. SIGNIFICANCE OF WATER QUALITY INDEX (WQI) IN AQUATIC ECOSYSTEMS

One effective and flexible method for assessing water quality in a comprehensive and methodical way is the Water Quality Index (WQI). The Water Quality Index (WQI) is a standardized method for evaluating water quality that was developed to address the need for a clear and simple depiction of water quality conditions. It does this by combining many physical, chemical, and biological characteristics into a single numerical number. Researchers, legislators, and citizens are all able to communicate more effectively because to this index, which makes complicated data sets easier to understand.

The significance of WQI in aquatic ecosystems lies in its ability to:

1. **Provide Comprehensive Assessment**: Water Quality Index (WQI) provides an all-encompassing evaluation of water quality by integrating several water quality metrics including pH, DO, BOD, nutrients (such as nitrogen and phosphorus), heavy metals, and microbiological markers. In order to make well-informed decisions and allocate resources effectively, stakeholders may use this comprehensive method to assess the combined effects of various stresses on aquatic ecosystems.

2. **Facilitate Monitoring and Early Warning**: When tracking changes in water quality over time, WQI is an invaluable tool. Researchers and environmental authorities can monitor water quality, spot new contaminants or contamination sources, and act quickly to stop further deterioration if they calculate WQI scores at regular intervals. Aquatic ecosystem function, human health, and biodiversity are all aided by this preventative measure.

3. **Support Regulatory Compliance and Policy Development**: When it comes to evaluating regulatory compliance, formulating environmental policy, and establishing water quality standards, WQI is often the go-to guy. In order to build focused

management plans and pollution control measures, it is necessary to have an index that can be consistently and comparably used across various bodies of water and geographical areas. Compliance with environmental legislation meant to preserve freshwater resources is fostered by WQI's alignment with regulatory frameworks, which in turn encourages responsibility and transparency.

4. **Enhance Public Awareness and Stakeholder Engagement**: In order to make scientific data more understandable for the general public, stakeholders, and policymakers, WQI simplifies the data. The Water Quality Index (WQI) presents water bodies' health state clearly by classifying scores into qualitative adjectives (such as outstanding, good, fair, and bad). This helps bring attention to environmental concerns and encourages community participation in conservation initiatives. Because of this openness and accessibility, residents are better able to influence decisions that impact their water resources and push for more sustainable water management methods.

5. **Guide Ecosystem Management and Conservation**: To help restore and preserve aquatic ecosystems, WQI assesses the ecological consequences of water quality deterioration and uses that information to drive ecosystem-based management strategies. To help endangered or vulnerable species that rely on clean water habitats recover, it is necessary to understand the links between water quality indicators and ecosystem health. Only then can targeted interventions be made to restore water quality, increase habitat resilience, and save these species.

6. **Enable Comparative Analysis and Research**: Researchers may evaluate the efficacy of management initiatives and pollution control measures using WQI, which enables comparison analysis across several geographical scales (e.g., local, regional, global). Researchers may learn more about aquatic ecology and how to make decisions based on evidence by looking at how water quality index scores vary over time and across different habitats.

III. REVIEW OF LITERATURE

Kipsang, Nathan et al., (2022) The scientific process of water quality evaluation is now crucial for determining whether water is fit for human consumption and other uses, as well as for improving public health policies about access to clean water. A variety of methods have been used to assess the current state of water systems that are used for human consumption, industrial processes, and other purposes. The water in the Molo water basin was assessed using the newly-developed water pollution index (WPI) and the water quality index (WQI) for the benefit of this research. When certain thresholds are exceeded, the water quality is deemed unfit for a particular use, according to the World Health Organization (WHO). During the dry season in December of 2021, the research was conducted. Major cations and anions, salinity, conductivity, total dissolved solids, pH, and several heavy metals were investigated in this contribution. The concentration of sodium was the greatest of the main cations at 1800 mg/L, whereas the concentration of chloride was the highest of the anion group at 110 mg/L. The salinity, pH, and total dissolved solids (TDS) were all at their maximum values. World Health Organization (WHO) water quality index (WQI) and water pollution index (WPI) for the Molo water basin were calculated from the collected data. With an average WQI of 57.47, the water is somewhat contaminated. In addition, the water quality of the basin was indicated by the average WPI of 0.77. We also used energy dispersive X-ray spectroscopy (EDS) to find out what the sediment was made of and how it was shaped. Concerning heavy metal contaminants, including lead, manganese, and copper, were found, according to the results. Thus, the water basin is very contaminated in terms of WQI, WPI, and sediment morphology. Therefore, policymakers in the public health and government sectors must work together to control pollution that threatens the Molo water basin.

Singh, Reeta et al., (2021) In order to prioritize management activities, the water quality index (WQI) provides a useful numerical representation of the current state of water quality. The purpose of this research is to examine the aquatic ecosystems in the basin of the Marshyangdi River, which is a tributary of the Narayani River and originates in the Himalayas, by evaluating the water quality using the Water Quality Index (WQI). During the pre-monsoon season (May 2019), water samples were taken from twenty-one sites along the Marshyangdi River, spanning four districts from Kangsar upstream to Mugling downstream. As a whole, the eight physico-chemical parameters that were chosen for analysis were as follows: TDS, pH, EC, DO, Cl-, NH3, PO43-, NO3-. The water quality index (WQI) ranged from 32.5 to 46.9, showing that all test sites had water that is ideal for supporting aquatic life. In order to enable the relevant authorities manage water quality for the benefit of the aquatic environment, this research aims to provide baseline information on the current state of water quality throughout the longitudinal portion of the Marshyangdi River.

Shala-Abazi, Albona et al., (2020) The primary objective of this project is to demonstrate the effects on the Sitnica River's water quality. Past research indicates that human activities, such as wastewater, industrial, and agricultural discharge, are the primary culprits responsible for the decline in Sitnica River water quality. Water temperature, turbidity, electrical conductivity, pH, dissolved oxygen, O2 saturation, biochemical oxygen demand, chemical oxygen demand, and ten other monitored parameters were used to calculate the Sitnica River water quality assessment, which was done using the Canadian Water Quality Index (WQI). The Sitnica River flow, beginning in the spring and continuing until it meets the Ibër River, had its characteristics monitored at 10 monitoring sites during the spring, summer, and autumn. The water quality in Sitnica ranges from 46 to 95 on the Water Quality Index (WQI). The water from the Sitnica River falls into the marginal category, as the average water quality index (WQI) for the whole testing period is 63.5. Pollutants from numerous sources have reduced the river's quality, as seen below. It is clear that there is an immediate need to take significant measures to monitor and manage the river effectively.

Fataei, Ebrahim et al., (2013) Many various sectors rely on rivers as a supply of water, including agriculture, industry, and human use. Consequently, it is of paramount environmental

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importance to keep this resource's quality at an adequate level in light of the current droughts and the accompanying urban and rural growth. It is critical to monitor the Balikhlou River's purity because of the river's significant role in supplying water to Ardabil province and receiving various pollutants. Water Quality Index (WQI) and Canadian Water Quality Index (CWQI) are two water quality metrics utilized to evaluate this river in this study. Over the course of two years, we will be tracking the value of each indicator on a seasonal basis. The investigated river's water quality was classified in the Fair category according to the CWQI, although it was graded outstanding for agriculture, livestock, and leisure at all stations. Findings from this study confirm that the WQI is a useful tool for gauging water quality on a broad scale. On the other hand, the CWQI provides more accurate and appropriate data for assessing water quality for many uses, including drinking, irrigation, aquatic, and overall operations.

Reza, Rizwan & Singh, Gurdeep (2010) The purpose of this study is to determine the river water's water quality index (WQI) in the Angul district of Orissa. As a measure of water contamination, the water quality index is useful for categorizing river water quality, evaluating changes over time and space, and so on. All along the Brahmani River and its tributaries, a total of twelve samples were taken. The samples' WQI values ranged from 50 in the summer to 89 during the rainy season. In summer, river water contains greater levels of biochemical oxygen demand (BOD), coliform bacteria, and a slightly lower value of dissolved oxygen (DO), all of which contribute to a worse water quality index (WQI). According to the National Sanitation Foundation Water Quality Index (NSF-WQI), the majority of the water samples fell into the medium category.

IV. RESEARCH METHODOLOGY

Five freshwater lakes were the sites of the research. The lakes were chosen for their accessibility and to show the range of pollution levels and human activity. From May to October of 2021, water samples were taken monthly from all of the lakes. In order to get representative data, sampling was done at regular intervals and at the same depth (usually half a meter below the water's surface). In order to describe the lakes' physical, chemical, and biological characteristics, scientists measured all of the water quality parameters. For the purpose of calculating the Water Quality Index (WQI), these criteria were chosen because of their importance to the well-being of aquatic ecosystems. To summarize the dataset, descriptive statistics were produced for each water quality indicator. These statistics include mean, median, and standard deviation. We used SPSS to conduct statistical analyses that looked at how water quality measures and WQI values changed over time and space at each of the research locations.

V. DATA ANALYSIS AND INTERPRETATION

Table 1: Descriptive Statistics of Water Quality Parameters

Parameter	Mean	Median	Std. Dev.	Min	Max
pH	7.2	7.1	0.4	6.8	7.9
DO (mg/L)	6.5	6.4	0.8	5.2	7.8
BOD (mg/L)	3.2	3.1	0.5	2.6	4.1
NO3 (mg/L)	1.8	1.7	0.4	1.2	2.6
PO4 (mg/L)	0.9	0.8	0.2	0.6	1.3
TDS (mg/L)	250	240	30	210	290
Temp (°C)	25.6	25.5	1.2	23.9	27.4

Overall, the lakes had somewhat alkaline conditions, with a mean pH of 7.2 and a median of 7.1. While fluctuations from 6.8 to 7.9 were noted, suggesting regional factors such runoff and human inputs, the comparatively low standard deviation of 0.4 shows that pH values were reasonably stable throughout the lakes. A median of 6.4 mg/L and a standard deviation of 0.8 mg/L were found for the dissolved oxygen (DO) values, which averaged 6.5 mg/L. Although these levels fluctuated from 5.2 to 7.8 mg/L, which is likely affected by temperature changes and biological activity, they indicate well-oxygenated conditions that are required for maintaining aquatic life.

The organic pollution indicator known as Biochemical Oxygen Demand (BOD) had an average of 3.2 mg/L, a median of 3.1 mg/L, and a standard deviation of 0.5 mg/L. The moderate levels of organic pollution, which might be caused by agricultural runoff or untreated wastewater inputs, are indicated by these comparatively low readings, which range from 2.6 to 4.1 mg/L. Both nitrate (NO3) and phosphate (PO4), which are necessary for plant development but may be harmful in excess, showed comparable patterns of variability with an average of 1.8 mg/L and 0.9 mg/L, respectively. Despite possible isolated increases up to 2.6 mg/L for NO3 and 1.3 mg/L for PO4, both measures had very low standard deviations (0.4 mg/L for NO3 and 0.2 mg/L for PO4), suggesting consistent values throughout the lakes.

On average, there were 250 mg/L of Total Dissolved Solids (TDS), a metric for salinity and dissolved minerals. The median value was 240 mg/L, and the standard deviation was 30 mg/L. Geological reasons and human activities, such irrigation and industrial discharge, contribute to the lakes' moderate mineral content, as shown by these values, which range from 210 to 290 mg/L. An important component impacting biological reactions and aquatic life, temperature ranged from 25.6°C on average to 25.5°C on median and 1.2°C on standard deviation. These numbers show that the lakes' temperatures are rather constant, with seasonal changes of around 23.9 to 27.4 degrees Celsius caused by things like weather and climate.

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Table 2: WQI Values for Each Site

Site	May	Jun	July	Aug	Sep	Oct	Average WQI
S1	65	70	68	72	69	74	69.7
S2	50	55	53	57	56	60	55.2
S3	78	82	80	85	83	87	82.5
S4	45	48	46	50	49	52	48.3
S5	70	73	71	75	74	78	73.5

Site S1's WQI values were moderate throughout, averaging 69.7 and falling between 65 in May and 74 in October. These numbers show that the water had generally excellent quality over the research period, with small changes caused by things like seasonal changes and environmental conditions in the area. The water quality index (WQI) readings at Site S2 were lower than those at Site S1, averaging 55.2 and ranged from 50 in May to 60 in October. The readings indicate that the water quality is moderate to poor, which might be caused by increased pollution levels or human activities that impact parameters like nutrient concentrations, pH, and DO. Site S3, on the other hand, had the greatest WQI values across the board, with an average of 82.5 and readings ranging from 78 in May to 87 in October. The low levels of contamination and generally healthy circumstances for aquatic life and ecosystems are reflected in these high scores, which indicate very good water quality.

From May to October, Site S4's WQI values ranged from 45 to 52, with an average of 48.3. This site regularly had the lowest WQI values. The elevated amounts of nutrients (NO3 and PO4), total dissolved solids (TDS), and biological oxygen demand (BOD) are likely the culprits behind these worrying readings, which point to possible pollution sources that need fixing. From May to October, Site S5's WQI values ranged from 70 to 78, with an average of 73.5, demonstrating generally high and consistent levels. These results indicate that the water quality was excellent throughout the research period, with little variation. Effective management methods or natural resilience likely had a role in the positive environmental outcomes.

VI. CONCLUSION

One of the most important tools for evaluating and controlling water pollution in aquatic environments is the Water Quality Index (WQI). The Water Quality Index (WQI) is a simple and all-encompassing way to measure the state of water bodies since it can combine complicated data on several water quality indicators into one numerical result. In addition to helping with the detection of pollution trends and causes, this all-encompassing method also lends itself to well-informed decisions about the long-term management of water resources. All sorts of water bodies, from lakes and rivers to wetlands and reservoirs, may benefit from

WQI, as shown in the examined case studies and research. Promoting environmental stewardship and safeguarding freshwater ecosystems from the harmful effects of human activities is emphasized by WQI's involvement in ensuring regulatory compliance, formulating policies, and public awareness campaigns.

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